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Description

Method of controlling the transmitting power in a mobile radio system and corresponding mobile radio system

The present invention relates to a method of controlling the transmitting power in a mobile radio system and to a corresponding mobile radio system.

In mobile radio systems, controlling the transmitting power represents an important feature in order to be able to stop possible interference between the individual connections and thus improve the capacity and quality of the connections and in order to be able to reduce the mean transmitting power and to adapt it to the requirements in the best possible way and compensate at least partially for losses through the transmission channels.

For this purpose, the signal transmitted by a transmitter is evaluated at the receiving end in the mobile radio system in order to be able to generate in dependence thereon information for the power control and transmit it to the transmitter which thereupon adjusts the transmitting power in accordance with the power control information.

In this process, the received level and/or the received quality of the transmit signal can be measured by the receiver and transmitted as actual values to the transmitter which correspondingly corrects the transmitting power in dependence on these actual values. This approach is used, for example, in the GSM (Global System for Mobile Communications) mobile radio systems. As an alternative, the receiver itself can also generate nominal values or, respectively, adjustment commands for the transmitting power in

dependence on the measured received level of the transmit signal and transmit these to the transmitter which thereupon correspondingly adjusts the transmitting power. This approach is used, for example, in CDMA (Code Division Multiple Access) mobile radio systems and, in particular, is provided in accordance with the current

state of UMTS (Universal Mobile Telecommunication System) standardization for UMTS mobile radio systems which are to be operated in accordance with a WCDMA (Wideband Code Division Multiple Access) method. In each approach, the power of the transmitter is always controlled in such a manner that, taking into consideration the current properties of the transmission channel, the power needed in each case arrives as accurately as possible at the receiver in spite of fading effects.

However, the transmitter can only react to the measurements of the receiver and the power information subsequently supplied to it with a certain delay which leads to a degradation of the transmission characteristic of the mobile radio system especially at higher speeds of the receiver.

To solve this problem, it has been proposed for CDMA mobile radio systems to achieve as short a response time or delay in the power control as possible by means of as high a power control frequency as possible and clever interleaving of the timeslots of the uplink and downlink connections. In particular, it has been provided in accordance with this proposal to shift the frame structure of the uplink connection, i.e. the connection between the mobile station and the base station, by 250 μs with respect to the frame structure of the downlink connection, i.e. the connection between the base station and the mobile station in order to provide for power control of the transmitting power with a time delay of only one timeslot if the symbol transmission rate of the downlink connection is higher than 16 ksps. This proposal is described, for example, in ARIB, Volume 3, Specification of Air Interface for 3G Mobile System, Version 0.5, Section 3.2.2.1.

However, the procedure described above places the burden on an accurate measurement of the channel impulse response of the

corresponding transmission channel which, however, is essential for assessing the behavior and the state of the transmission channel since, due to certain operating conditions, signal distortion can occur which renders information transmission impossible in the most extreme case. In mobile radio systems, therefore, the current channel impulse response is measured in the receiver in order to be able to subsequently correct, if necessary, signal distortion found, using corresponding equalizers.

For this reason, the present invention is based on the object of creating an improved method of controlling the transmitting power in a mobile radio system and a corresponding mobile radio system by means of which the influence of delays in the power control can be eliminated as completely as possible.

According to the invention, this object is achieved by a method having the features of claim 1 and, respectively, a corresponding radio mobile system having the features of claim 11. The subclaims in each case describe preferred and advantageous embodiments of the present invention.

According to the invention, it is proposed to estimate the behavior of the transmission channel and, depending on this the transmitting power needed so that the power control information to be transmitted to the transmitter can be generated on the basis of the estimated transmitting power needed.

In particular, the behavior with time or the state of the respective transmission channel is predicted so that the transmitting power needed in future can be estimated in dependence thereon. In contrast to the known state of the art, the power control information

which represents the basis for the adjustment of the transmitting power at the transmitting end is not based on the instantaneous measured value

of the received level or of the received quality of the transmit signal but on the above-described prediction of the channel state and the transmitting power needed in future. In this manner, the influence of delays can be eliminated in the power control of the transmitting power if the behavior of the transmission channel can be predicted with sufficient accuracy.

The behavior of the channel state can be estimated, for example, via the channel impulse response.

The invention can be combined with other methods for determining the power control information and the proportion of the method of the present invention in the determination of the power control information to be transmitted to the transmitter is reduced or completely eliminated with increasing speed of the receiver or, respectively, the mobile station since accurate estimates become ever more difficult with increasing speeds.

In the text which follows, the invention is explained in greater detail, referring to the attached drawing, in which:

fig. 1 shows a diagrammatic representation for explaining the principle forming the basis of the present invention,

fig. 2 shows a diagrammatic representation of a mobile radio system for explaining the information transmission in the power control, and

fig. 3 shows the frame and timeslot pattern for a so-called downlink connection according to the current state of UMTS standardization.

Figure 2 shows the communication between a base station 1 and a mobile radio station 2 of a mobile radio system. A connection from the base station 1 to the mobile part 2 is

called downlink or forward link connection whereas a connection from the mobile part 2 to the base station 1 is called uplink or reverse link connection. To control the power of the downlink, the respective received signal is evaluated in the mobile station 2 and, depending on this, a power control information item is generated and sent back to the base station 1 so that the base station 1 can correspondingly adjust the transmitting power. To control the uplink, the received signal is evaluated in the base station 1, where the power control information is generated and the mobile station 2 is instructed for power matching.

The power information item is transmitted in dependence on the respective mobile radio system linking with a predetermined frame structure.

Figure 3 shows the frame and timeslot structure for a downlink connection via a UMTS mobile radio channel, also called DPCH (Dedicated Physical Channel), the present invention being applied preferably to corresponding UMTS mobile radio systems. The frame structure with a period of 720 ms comprises, in particular, 72 identically structured frames 3 with a frame period of 10 ms, each frame, in turn, having in each case 16 timeslots 4 with a timeslot period of 0.625 ms. Each timeslot 4 comprises bit information which is divided into a logical control channel (DPCCH - Dedicated Physical Control Channel) and a logical data channel (DPDCH - Dedicated Physical Data Channel). The bits of the DPCCH section comprise a pilot bit sequence 5 and so called TPC (Transmitter Power Control) controlled bits 6 and TFI (Transmitter Format Identifier) control bits 7. The DPDCH section comprises user data bits 8. The structure shown in figure 3 can be found, for example, in the document ETSI STC SMG2 UMTS - L1: Tdoc SMG2 UMTS-L1 221/98.

The pilot bit sequence 5 is used for estimating the channel impulse response during a so called training sequence, as already mentioned above, and corresponds to a known bit pattern. If the pilot bit sequence is called s(t), the channel impulse response h(t) and the received signal or, respectively, the training sequence is called r(t), the following holds true:

$$r(t) = s(t) * h(t).$$

The receiver can thus determine or estimate the channel impulse response h(t) of the mobile radio channel by comparing the received signal r(t) with the known pilot bit sequence s(t), the signal-matched filters, for example, being used for this purpose which calculate the channel impulse response h(t) by calculating the correlation between the received signal r(t) and the pilot bit sequence s(t).

The TPC bits 6 comprise the power control information, and in UMTS mobile radio systems the received signal is evaluated and compared with predetermined quality requirements or reference values in the receiver. Depending on this comparison, the receiver generates a control command and transmits it in the form of the TPC bit field 6 to the transmitter in order to instruct the latter to correspondingly adapt the transmitting power.

In the text which follows, the principle forming the basis of the present invention is explained with reference to figure 1.

The time response or state of the transmission channel is predicted in order to be able to estimate, in dependence thereon, the transmitting power needed in future. The behavior of the transmission channel can be assessed, in particular, via the channel impulse response.

In the representation of figure 1 it will be assumed that, at the moment, the transmitting power for timeslot n is to be determined in order to be able to transmit a corresponding power control command to the transmitter. The values of the channel impulse responses, measured by means of the pilot bit sequences 5 transmitted in the respective timeslots for timeslots n-2 and n-1, and the values P_{n-2} and P_{n-1}, respectively, for the transmitting power determined for these timeslots are known in the receiver such that the receiver can extrapolate the future channel state or the transmitting power P_n needed for timeslot n in future on the basis of these known values which is indicated by a dashed line in figure 1. This extrapolated power value P_n is then used by the receiver for controlling the transmitting power, i.e. used as a basis for the power control information 6 to be transmitted to the transmitter.

Thus, the variation of the fast fading is predicted as far as possible, assuming, as a rule, Rayleigh fading. When so called rake receivers are used, the prediction is performed for every rake finger. In rake receivers, the received signal is processed in a number of paths, the so called rake fingers. Each of these rake fingers is adjusted with optimized phase angle to a multi-path signal in order to achieve an increasing gain with the presence of multipath signals which arrive at the receiving antenna with different propagation delay. Deep fading dips occur whenever the channel impulse response exhibits an (approximate) zero transmission for all or at least the dominant paths. This circumstance can be reliably predicted if both the intervals of the estimation of the channel impulse response and the period of prediction are selected to be shorter than the so called coherence time of the transmission channel, in order to provide for reasonable data detection. The period of prediction

is shorter than the coherence time of the transmission channel at least at low to medium speeds of the mobile station 2.

As shown in figure 1, the channel impulse response measured for the past can be linearly extrapolated for predicting the transmitting power needed in future. Naturally, however, other approaches are also conceivable.

At high speeds of the mobile station 2, an accurate and reliable prediction of the future behavior of the transmission channel and of the transmitting power needed in future, respectively, can be difficult. For this reason, it is provided in accordance with an exemplary embodiment of the invention, in determining the power control information 6, to combine the principle according to the invention with other principles with the aid of which the power control information can be determined, where the proportion of the prediction according to the invention of the determination of the power control information can be reduced or completely eliminated in dependence on the characteristic behavior of the transmission channel, e.g. at higher speeds of the mobile station 2.

Thus, for example, the method according to the invention can only be used in a particular speed range of the mobile station 2 which is not too high whilst otherwise the power control information 6 is conventionally determined by means of the instantaneously measured level of the received signal since the conventional non-predictive power control method is quite adequate for satisfactory control of the transmitting power, for example at low speeds of the mobile station 2.

However, it is particularly advantageous if the switching between the invention and the further method for determining

the power control information is not "hard" but "soft". Thus, the nominal value used for the transmitting power in a certain speed range can be, for example, a value which is composed of 70% of the current measured value of the received power and of 30% of the value predicted according to the invention, i.e. the nominal value for the transmitting power is based on a weighting of various values which have been determined in different ways, one of these values having been determined according to the invention. In this case, it can be said that the received power and the nominal transmitting power derived therefrom are not calculated in advance by one timeslot 4 but by a fraction a of a timeslot, a representing a correction factor and reflecting the reliability of the prediction. The correction factor a can have values between 0 and 1 and is 0.3 in the example described above.

In the above description, it has been assumed that the behavior or the state of the transmission channel is predicted by estimating the channel impulse response. However, it is also possible to predict instead the so called carrier/interferer ratio C/I in order to derive therefrom the transmitting power needed in future. Similarly, it is also possible to predict only the component C (corresponding to the carrier signal) or the component I (corresponding to the interference) in order to estimate the transmitting power needed in future.